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CHEMISTRY OF THE ATMOSPHERE OF THE PLANET VENUS

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Microwave Emission from Chemical Reactions

Three different experimental arrangements are now being used for the investigations of the emission of microwave radiation by chemical reactions. The first is an ordinary X-band waveguide noise generator with the argon discharge tube replaced by a 6 mm Pyrex tube connected to a vacuum rack. This arrangement permitted the study of various other gases. The microwave receiver was carefully calibrated with a Polarad calibrated output signal generator. Accurate measurements were then made on the radiation emitted from glow discharges in argon, air, CO_2 and SO_2. In each case the discharge power and the gas pressure were maintained as nearly identical as possible. The measurements were made in a flowing system at pressures of about 1 mm. The results are shown in the following table:

Table I

Microwave Intensities Observed from Glow Discharges in Various Gases

Gas	Microwave Intensity, watts (1 Mc bandwidth at 10,000 Mc)	"Electron Temperature," Calculated, °K
Argon	3×10^{-13}	6,000
Air	6×10^{-13}	12,000
CO_2	2×10^{-11}	4×10^{5}
SO_2	1.5×10^{-9} to 2.5×10^{-8}	3×10^{7} to 5×10^{8}

The values for argon and air represent observations near the lower limit of the receiver where the precision for measurement of a noise signal is not the best. Thus, within the errors of measurement the values obtained for

for electron temperatures correspond to those reported in the literature. With CO_2 and SO_2, however, the intensities observed are very high and, if attributed solely to electron temperature, give values that are unreasonably high. Thus, the emission observed must be due to some other cause in addition to the electron temperature.

A real test of whether the origin of the emission may be the continua associated with the chemiluminescent reactions occuring in the discharges would be to see whether such emission can be observed from the reactions alone, outside any discharge. This test cannot be carried out using the noise generator because the oxygen atoms recombine on the walls of the 6 mm tubing before any glow reaches the detection area. To overcome this difficulty two alternate systems have been set up. The first used a 12'' length of S-band waveguide connected by standard waveguide tapers to an X-band pickup. The chemiluminescent reaction gases are contained inside a 30 mm diameter U-tube which is placed in the S-band end of the system. Calibration with the signal generator indicates that there may be as much as 15 db loss in this system from the S-band to the X-band end. Nevertheless, the large diameter tubing makes it possible to obtain a large volume of a high intensity glow and studies now in progress appear promising.

The final experimental arrangement incorporates an 18'' length of square X-band waveguide connected by tapers to an ordinary rectangular X-band pickup. The reaction gases are led into and out of a 20 mm diameter glass tube inside the square waveguide through an inlet and outlet manifolds connected to the inside vessel by a series of parallel tubes of small diameter but short length. These tubes pass through holes drilled through the center of the wide side of the waveguide. Checking with the signal generator shows no losses occurring in this system. However, because of small diameters of the inlet and outlet tubes it is difficult to get a high intensity glow inside the waveguide. Several improvements to this system are being made in an effort to overcome this difficulty.

From our experiments it seems obvious that any microwave emission from the reaction glows will be at an intensity near the lower limit of our receiver. Therefore we have been investigating the possibility of improving the sensitivity. We have been able to arrange for the loan of a very sensitive low noise traveling wave tube amplifier for evaluation and this should be on hand in the near future. From the results obtained to date it seems reasonable to conclude that the microwave radiation emitted from Venus may originate in part from a non-thermal source and thus the surface temperature may be lower than that reported in recent literature.

<u>Photochemistry with Iodine Lamp</u>

A series of experiments has been carried out irradiating nitric oxide with the iodine lamp. The 2062 A line excites the NO molecule to the third vibrational level of the $B^2\Pi$ excited state (β system). We have found that these excited NO molecules then undergo reaction in all of three possible ways:

$$NO^* + NO \rightarrow \quad a)\ NO_2 + N$$

$$b)\ N_2O + O$$

$$c)\ N_2 + O + O$$

The N_2O concentration remained very low throughout the irradiation because this molecule also undergoes photolysis with the 2062 A line. During the initial experiments significant amounts of the 1876 A line were also transmitted by the quartz to the NO molecules. Under these conditions it was found that the NO_2 formed also reacted away and the end products of the photolysis were simply N_2 and O_2.

Liquid CO was irradiated with an end-window iodine lamp using a cell which could be cooled to liquid nitrogen temperature. One objective was to find out whether this might be a feasible method for obtaining carbon suboxide in appreciable quantities. It was found that the CO $a^3\Pi$ molecules react to form CO_2 just as in the gas phase, but with an efficiency only about 1/10 as great. For this reason no substantial amounts of carbon suboxide were formed even after irradiations of as long as 100 hours.

Photochemistry with Bromine Lamp

A new photochemical lamp has been developed using bromine in place of iodine. Since the bromine lines are at 1633 A and 1582 A the inner discharge tube of the lamp was constructed of Suprasil quartz which has excellent transmission properties in this wavelength region. To date only preliminary experiments have been carried out using this lamp. We have examined the equilibrium between oxygen and ozone using a flowing system and also the equilibrium between carbon dioxide and its dissociation products using a static system. These and other systems of basic importance to the understanding of planetary atmospheres will be studied in detail. The lamp intensity appears to be about 3 x 10^{17} quanta/sec over the length of the tube which is sufficient to permit equilibrium to be obtained very rapidly and makes possible fundamental kinetic studies that could not previously be carried out. A paper describing the lamp and some of the experimental results obtained with it is now in preparation.

Presentations

Dr. Harteck and Dr. Reeves presented a paper entitled "Photochemical Reactions of Excited Molecules", at the Photochemical Symposium held at the University of California, Davis, California in June 1964.